

## Introduction

### Remote Classroom Interaction:

- Allows for real time transmission of voice and full motion video.
- Permits for live discussion and immediate feedback.
- Creates a social presence.

### Limitations of Existing Remote Classroom Interaction Systems:

- Use traditional cameras, thereby providing a limited number of static or manually tracked views.
- Cannot localize multiple speakers in the audio domain.
- Detecting students wishing to interact with the instructor.

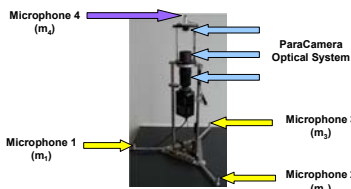
## Project Goals

### Develop a teleconferencing system integrating audio and video cues.

- In a multiple student setting, being capable of attending to a student signaling their intent to interact with the instructor:
  - Students may speak or raise their hand to attract instructor's attention.
  - In this work, we address signaling by hand raising gestures.

## Hardware

### Novel Sensor Combining Audio and Video Systems:

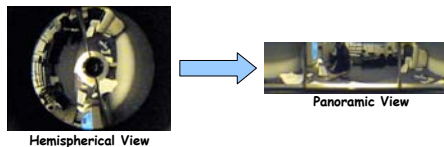


- Economical, lightweight and portable.
- Mounted in a remote classroom.

## Video System

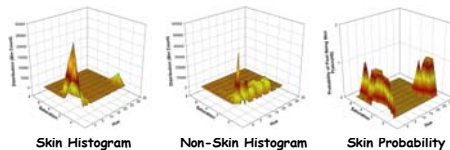
### Omni-directional Video Sensor (Cyclovision's ParaCamera) Captures a View of the Entire Visual Hemisphere from a Single Viewpoint:

- Hemispherical View is easily "un-warped", allowing for multiple dynamic views of the scene.

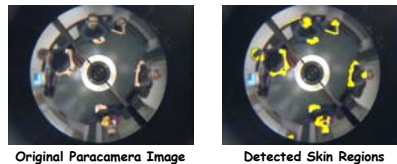


### Color Based Human Skin Classification:

- HSV Color models for both *skin* and *non-skin* colors, constructed by manually classifying portions of ParaCamera images as either skin or non-skin.



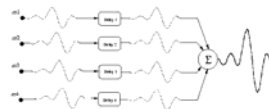
- Bayes' rule is used to classify the pixels of each image as either skin or non-skin.
  - Regions of "skin" pixels are grouped together.
- Estimate of the direction of each skin region in the real world can be made, and provided to the audio system.



## Audio System

### Beamforming Focuses Four Microphones ( $m_1 \dots m_4$ ) to the Direction of the Skin Region:

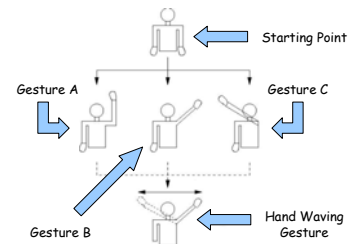
- Appropriately delaying the signal of each microphone ensures the signals are in phase.
- Signal is reinforced, while noise and sound emanating from other directions are attenuated.



## Raising Hand Gestures Defined

### Students wishing to interact with instructor will raise their hand:

- Difficult to detect raising hand gestures due to the large variation.
  - Trajectory followed by arm doesn't follow any set pattern or path.
  - May move straight up, diagonally to the left/right etc.
- Rather than a single gesture, several raising hand gestures are defined.



- **Starting Point:** Prior to Raising the hand, it is at some position below the head.
- **Gesture A:** Hand raised straight upward from starting point to above the head.
- **Gesture B and C:** Hand raised upward diagonally to the right/left respectively.
- **Hand Waving Gesture:** After hand is raised, it may possibly be waved.

## Detecting Hand Raising Gestures

### Manual classification of ParaCamera images in simulated classroom setting:

- Construction of statistical models capturing info. when hand is raised.
  - Hand motion patterns.
  - "Form" of skin region corresponding to the hand e.g. size, length vs. width.

### The Statistical Models and a Bayesian Framework are Used to Classify Detected Skin Regions of Incoming ParaCamera Images:

- Students raising their hand can be detected.
  - Beamformer focused in direction of the student wishing to interact.